

1. Uraian perhitungan

1.1 Data pengamatan

Bioinhibitor	: Ekstrak daun belimbing wuluh
Temperatur	: 31° C
Warna	: hijau muda
pH	: 3,46
volume	: 5 mL
Media	: Pelat baja karbon
Panjang pelat	: 4 cm
Lebar pelat	: 2,6 cm
Tebal pelat	: 0,24 cm
Larutan korosif	: HCl (1M, 2M, 3M, 4M, dan 5M)
Volume	: 100 mL
Temperatur	: 28° C

1.2 Perhitungan

1.2.1 Pembuatan larutan media perendaman

Diketahui :

ρ_{HCl} : 1,159 gr/mL

BM : 36,5 gr/mol

% : 32

Penyelesaian :

Konsentrasi HCl 32%

$$M = \frac{\rho \times \% \times 1000 \text{ mL}}{BM}$$

$$= \frac{1,159 \frac{\text{gr}}{\text{mL}} \times 0,32 \times 1000 \text{ mL}}{36,5 \text{ gr}}$$

$$M = 10,161$$

Konsentrasi HCl 1M

$$V_1 M_1 = V_2 M_2$$

$$V_1 \times 10,161 \text{ M} = 100 \text{ mL} \times 1\text{M}$$

$$V_1 = \frac{100 \text{ mL} \times 1\text{M}}{10,161 \text{ M}}$$

$$V_1 = 9,8415 \text{ mL}$$

Konsentrasi HCl 2M

$$V_1 M_1 = V_2 M_2$$

$$V_1 \times 10,161 \text{ M} = 100 \text{ mL} \times 2\text{M}$$

$$V_1 = \frac{100 \text{ mL} \times 2\text{M}}{10,161 \text{ M}} = 19,6831 \text{ mL}$$

Konsentrasi HCl 3M

$$V_1 M_1 = V_2 M_2$$

$$V_1 \times 10,161 \text{ M} = 100 \text{ mL} \times 3\text{M}$$

$$V_1 = \frac{100 \text{ mL} \times 3\text{M}}{10,161 \text{ M}}$$

$$V_1 = 29,5246 \text{ mL}$$

Konsentrasi HCl 4M

$$V_1 M_1 = V_2 M_2$$

$$V_1 \times 10,161 \text{ M} = 100 \text{ mL} \times 4\text{M}$$

$$V_1 = \frac{100 \text{ mL} \times 4\text{M}}{10,161 \text{ M}}$$

$$V_1 = 39,3662 \text{ mL}$$

Konsentrasi HCl 5M

$$V_1 M_1 = V_2 M_2$$

$$V_1 \times 10,161 \text{ M} = 100 \text{ mL} \times 5\text{M}$$

$$V_1 = \frac{100 \text{ mL} \times 5\text{M}}{10,161 \text{ M}}$$

$$V_1 = 49,2077 \text{ mL}$$

1.2.2 Perhitungan analisa kadar *tannin*

Diketahui :

Massa kristal asam oksalat	: 630 mg = 6,3 gr
Volume titran KMnO_4 (standarisasi)	: 27,3 mL = 0,0273 L
BM asam oksalat	: 126 g/mol
A (Volume titrasi titran KMnO_4)	: 15,7333 mL = 0,0157 L
B (Volume titrasi blanko)	: 14,3 mL = 0,0143 L
Massa sampel	: 1,5 gram

Penyelesaian :

$$\begin{aligned}
 N \text{ KMnO}_4 &= \frac{\frac{w}{BM} \times 2 \times \frac{25}{100}}{\text{Volume titran}} \\
 &= \frac{\frac{6,3 \text{ g}}{126 \text{ g/mol}} \times 2 \times \frac{25}{100}}{0,0273 \text{ L}} = 0,09
 \end{aligned}$$

Kadar *tannin* pada ekstrak daun belimbing wuluh

$$\begin{aligned}
 \% \text{ tannin} &= \frac{10 (A-B) \times N \times 0,00416}{\text{massa sampel (gr)}} \times 100\% \\
 &= \frac{10 (15,7333 \text{ mL} - 14,3 \text{ mL}) \times 0,09 \times 0,00416}{1,5 \text{ gram}} \times 100\% \\
 &= 0,3577 \%
 \end{aligned}$$

1.2.3 Perhitungan laju korosi dengan penambahan inhibitor

1. Konsentrasi HCl 1M

1.1 Waktu perendaman 1 minggu (168 jam)

1.1.1 Massa pelat

Berat awal : 17,7088 gr

Berat akhir : 17,3669 gr

Massa = Berat awal – berat akhir

= 17,7088 gr - 17,3669 gr

= 0,3419 gr

1.1.2 Konstanta : $3,45 \times 10^6$ mpy

1.1.3 Luas permukaan (A)

panjang : 4 cm

lebar : 2,6 cm

tebal : 0,24 cm

$$\begin{aligned} A &= 2 ((p \times l) + (l \times t) + (p \times t)) \\ &= 2 ((4 \text{ cm} \times 2,6 \text{ cm}) + (2,6 \text{ cm} \times 0,24 \text{ cm}) + (4 \text{ cm} \times 0,24 \text{ cm})) \\ &= 23,968 \text{ cm}^2 \end{aligned}$$

1.1.4 Densitas pelat

massa awal : 17,7088gr

A : 23,968 cm²

$$\begin{aligned} \rho &= \frac{\text{massa awal}}{A} \\ &= \frac{17,7088 \text{ gr}}{23,968 \text{ cm}^2} \\ &= 7,0948 \frac{\text{gr}}{\text{cm}^2} \end{aligned}$$

1.1.5 Laju korosi

Konstanta (K) = $3,45 \times 10^6$ mpy

Massa (w) = 0,3419 gr

A = 23,968 cm²

Densitas (D) = $7,0948 \frac{\text{gr}}{\text{cm}^2}$

Waktu (T) = 168 jam

$$\begin{aligned} \text{Laju korosi} &= \frac{K \times w}{A \times T \times D} \\ &= \frac{3,45 \times 10^6 \text{ mpy} \times 0,3419 \text{ gr}}{23,968 \text{ cm}^2 \times 168 \text{ jam} \times 7,0948 \frac{\text{gr}}{\text{cm}^2}} \\ &= 41,2888 \text{ mpy} \end{aligned}$$

Konversi :

$$\begin{aligned}
 \text{Laju korosi} &= 41,2888 \text{ mpy} \times \frac{0,547 \frac{\text{gr}}{\text{m}^2 \text{hari}}}{1 \text{ mpy}} \\
 &= 22,5849 \frac{\text{gr}}{\text{m}^2 \text{hari}} \\
 &= 22,5849 \frac{\text{gr}}{\text{m}^2 \text{hari}} \times \frac{7 \text{ hari}}{1 \text{ minggu}} \\
 &= 158,0948 \frac{\text{gr}}{\text{m}^2 \text{minggu}}
 \end{aligned}$$

1.2 Waktu perendaman 2 minggu (336 jam)

1.2.1 Massa pelat

Berat awal : 17,7088 gr

Berat akhir : 16,8891 gr

Massa = Berat awal – berat akhir

$$= 17,0888 \text{ gr} - 16,8891 \text{ gr}$$

$$= 0,8197 \text{ gr}$$

1.2.2 Konstanta : $3,45 \times 10^6$ mpy

1.2.3 Luas permukaan (A)

panjang : 4 cm

lebar : 2,6 cm

tebal : 0,24 cm

$$A = 2 ((p \times l) + (l \times t) + (p \times t))$$

$$= 2 ((4 \text{ cm} \times 2,6 \text{ cm}) + (2,6 \text{ cm} \times 0,24 \text{ cm}) + (4 \text{ cm} \times 0,24 \text{ cm}))$$

$$= 23,968 \text{ cm}^2$$

1.2.4 Densitas pelat

massa awal : 17,7088 gr

A : 23,968 cm²

$$\rho = \frac{\text{massa awal}}{A}$$

$$= \frac{16,1645 \text{ gr}}{23,968 \text{ cm}^2} = 7,0948 \frac{\text{gr}}{\text{cm}^2}$$

1.2.5 Laju korosi

$$\text{Konstanta (K)} = 3,45 \times 10^6 \text{ mpy}$$

$$\text{Massa (w)} = 0,8197 \text{ gr}$$

$$A = 23,968 \text{ cm}^2$$

$$\text{Densitas (D)} = 7,0948 \frac{\text{gr}}{\text{cm}^2}$$

$$\text{Waktu (T)} = 336 \text{ jam}$$

$$\begin{aligned} \text{Laju korosi} &= \frac{K \times w}{A \times T \times D} \\ &= \frac{3,45 \times 10^6 \text{ mpy} \times 0,8197 \text{ gr}}{23,968 \text{ cm}^2 \times 336 \text{ jam} \times 7,0948 \frac{\text{gr}}{\text{cm}^2}} \\ &= 49,4966 \text{ mpy} \end{aligned}$$

Konversi :

$$\begin{aligned} \text{Laju korosi} &= 49,4966 \text{ mpy} \times \frac{0,547 \frac{\text{gr}}{\text{m}^2 \text{hari}}}{1 \text{ mpy}} \\ &= 27,0746 \frac{\text{gr}}{\text{m}^2 \text{hari}} \\ &= 27,0746 \frac{\text{gr}}{\text{m}^2 \text{hari}} \times \frac{7 \text{ hari}}{1 \text{ minggu}} \\ &= 189,5150 \frac{\text{gr}}{\text{m}^2 \text{minggu}} \end{aligned}$$

Dengan cara perhitungan yang sama, hasil perhitungan laju korosi yang terdapat pada konsentrasi HCl 2M, 3M, 4M, dan 5M (dengan penambahan *bioinhibitor*).

Dapat dilihat pada tabel berikut :

Tabel 1. Hasil perhitungan (Dengan *bioinhibitor*)

Konsentrasi M	waktu (minggu)	w (gram)	Densitas (ρ)	Laju korosi		
				(mpy)	g/m ² hari	g/m ² minggu
1	1	0,3419	7,0948	41,2888	22,5849	158,0949
	2	0,8197		49,4946	27,0735	189,5150
	3	1,3898		55,7248	30,4814	134,9521
	4	2,3304		70,0790	38,3332	268,3326
	5	3,2006		76,9979	42,1178	294,8251
2	1	0,6421	7,1012	77,4722	42,3773	296,6413
	2	1,4902		89,8997	49,1751	344,2259
	3	2,7013		108,6413	59,4268	415,9878
	4	3,6682		110,6462	60,5235	423,6645
	5	4,7095		113,6445	62,1635	435,1448
3	1	0,7515	7,1336	80,7660	44,1790	309,2532
	2	1,5631		93,8691	51,3464	359,4248
	3	2,7378		109,6090	59,9561	419,6930
	4	3,7039		111,2154	60,8348	425,8440
	5	4,801		115,3261	63,0833	441,5837
4	1	1,2041	6,99619	147,4615	80,6614	564,6301
	2	2,4402		149,4209	81,7332	572,1329
	3	3,9118		159,6877	87,3491	611,4443
	4	5,2773		161,5726	88,3802	618,6618
	5	6,9346		169,8507	92,9083	650,3587
5	1	1,9543	7,1645	233,7118	127,8403	894,8826
	2	4,1573		248,5826	135,9747	951,8231
	3	6,2884		250,6734	137,1184	959,8288
	4	8,8442		264,4162	144,6356	1012,4496
	5	11,1529		266,7517	145,9132	1021,3925

1.2.4 Perhitungan laju korosi tanpa penambahan inhibitor

1. Konsentrasi HCl 1M

1.1 Waktu perendaman 1 minggu (168 jam)

1.1.1 Massa pelat

Berat awal : 15,1751 gr

Berat akhir : 13,3814 gr

Massa = Berat awal – berat akhir

$$= 15,1751 \text{ gr} - 13,3814 \text{ gr}$$

$$= 1,7937 \text{ gr}$$

1.1.2 Konstanta : $3,45 \times 10^6$ mpy

1.1.3 Luas permukaan (A)

panjang : 4 cm

lebar : 2,6 cm

tebal : 0,24 cm

$$A = 2 ((p \times l) + (l \times t) + (p \times t))$$

$$= 2 ((4 \text{ cm} \times 2,6 \text{ cm}) + (2,6 \text{ cm} \times 0,24 \text{ cm}) + (4 \text{ cm} \times 0,24 \text{ cm}))$$

$$= 23,968 \text{ cm}^2$$

1.1.4 Densitas pelat

massa awal : 15,1751 gr

A : 23,968 cm²

$$\rho = \frac{\text{massa awal}}{A}$$

$$= \frac{15,1751 \text{ gr}}{23,968 \text{ cm}^2}$$

$$= 6,0797 \frac{\text{gr}}{\text{cm}^2}$$

1.1.5 Laju korosi

$$\text{Konstanta (K)} = 3,45 \times 10^6 \text{ mpy}$$

$$\text{Massa (w)} = 1,7937 \text{ gr}$$

$$A = 23,968 \text{ cm}^2$$

$$\text{Densitas (D)} = 6,0797 \frac{\text{gr}}{\text{cm}^2}$$

$$\text{Waktu (T)} = 168 \text{ jam}$$

$$\begin{aligned} \text{Laju korosi} &= \frac{K \times w}{A \times T \times D} \\ &= \frac{3,45 \times 10^6 \text{ mpy} \times 1,7937 \text{ gr}}{23,968 \text{ cm}^2 \times 168 \text{ jam} \times 6,0797 \frac{\text{gr}}{\text{cm}^2}} \\ &= 252,7789 \text{ mpy} \end{aligned}$$

Konversi :

$$\begin{aligned} \text{Laju korosi} &= 252,7789 \text{ mpy} \times \frac{0,547 \frac{\text{gr}}{\text{m}^2 \text{hari}}}{1 \text{ mpy}} \\ &= 138,2700 \frac{\text{gr}}{\text{m}^2 \text{hari}} \\ &= 138,2700 \frac{\text{gr}}{\text{m}^2 \text{hari}} \times \frac{7 \text{ hari}}{1 \text{ minggu}} \\ &= 967,8904 \frac{\text{gr}}{\text{m}^2 \text{minggu}} \end{aligned}$$

1.2 Waktu perendaman 2 minggu (336 jam)

1.2.1 Massa pelat

$$\text{Berat awal} : 15,1751 \text{ gr}$$

$$\text{Berat akhir} : 12,7819 \text{ gr}$$

$$\begin{aligned} \text{Massa} &= \text{Berat awal} - \text{berat akhir} \\ &= 15,1751 \text{ gr} - 12,7819 \text{ gr} \\ &= 2,3932 \text{ gr} \end{aligned}$$

1.2.2 Konstanta : $3,45 \times 10^6$ mpy

1.2.3 Luas permukaan (A)

panjang : 4 cm

lebar : 2,6 cm

tebal : 0,24 cm

$$\begin{aligned}
 A &= 2 ((p \times l) + (l \times t) + (p \times t)) \\
 &= 2 ((4 \text{ cm} \times 2,6 \text{ cm}) + (2,6 \text{ cm} \times 0,24 \text{ cm}) + (4 \text{ cm} \times 0,24 \text{ cm})) \\
 &= 23,968 \text{ cm}^2
 \end{aligned}$$

1.2.4 Densitas pelat

massa awal : 15,1751 gr

A : 23,968 cm²

$$\begin{aligned}
 \rho &= \frac{\text{massa awal}}{A} \\
 &= \frac{15,1751 \text{ gr}}{23,968 \text{ cm}^2} = 6,0797 \frac{\text{gr}}{\text{cm}^2}
 \end{aligned}$$

1.2.5 Laju korosi

Konstanta (K) = 3,45 x 10⁶ mpy

Massa (w) = 2,3932 gr

A = 23,968 cm²Densitas (D) = 6,0797 $\frac{\text{gr}}{\text{cm}^2}$

Waktu (T) = 336 jam

$$\begin{aligned}
 \text{Laju korosi} &= \frac{K \times w}{A \times T \times D} \\
 &= \frac{3,45 \times 10^6 \text{ mpy} \times 2,3932 \text{ gr}}{23,968 \text{ cm}^2 \times 336 \text{ jam} \times 6,0797 \frac{\text{gr}}{\text{cm}^2}} \\
 &= 168,6320 \text{ mpy}
 \end{aligned}$$

Konversi :

$$\begin{aligned}
 \text{Laju korosi} &= 168,6320 \text{ mpy} \times \frac{0,547 \frac{\text{gr}}{\text{m}^2 \text{hari}}}{1 \text{ mpy}} \\
 &= 92,2417 \frac{\text{gr}}{\text{m}^2 \text{hari}}
 \end{aligned}$$

$$= 645,6919 \frac{gr}{m^2 \text{minggu}}$$

Dengan cara perhitungan yang sama, hasil perhitungan laju korosi yang terdapat pada konsentrasi HCl 2M, 3M, 4M, dan 5M (tanpa menggunakan *bioinhibitor*).

Dapat dilihat pada tabel berikut :

Tabel 1. Hasil perhitungan (Tanpa *bioinhibitor*)

Konsentrasi M	waktu (minggu)	w (gram)	Densitas (ρ)	Laju korosi		
				(mpy)	g/m ² hari	g/m ² minggu
1	1	1,7937	6,0797	252,7789	138,2700	967,8904
	2	2,3932		168,6320	92,2417	645,6919
	3	2,8847		135,5097	74,1238	518,8667
	4	2,8978		102,0938	55,8453	390,9172
	5	3,9982		81,6863	44,6824	312,7769
2	1	3,7081	6,9701	455,8135	249,3299	1745,3099
	2	7,7097		473,8525	259,1973	1814,3814
	3	8,0922		331,5744	181,3712	1269,5987
	4	8,1374		250,0699	136,7882	957,5176
	5	8,2062		201,7473	110,3558	772,4906
3	1	3,5423	6,6361	457,3492	250,1700	1751,1902
	2	8,5684		553,1365	302,5656	2117,9598
	3	9,4967		408,7088	223,5637	1564,9463
	4	9,7448		314,5397	172,0532	1204,3727
	5	10,4675		270,2934	147,8505	1034,9537
4	1	5,2519	6,6556	676,0892	369,8208	2588,7458
	2	8,5295		549,0111	300,3091	2102,1637
	3	9,0312		387,5357	211,9820	1483,8745
	4	9,2777		298,5849	163,3259	1143,2818
	5	9,412		242,3257	132,5521	927,8651
5	1	6,2194	7,1312	747,2454	408,7432	2861,2028
	2	10,0645		604,6123	330,7229	2315,0606
	3	10,9795		439,7198	240,5267	1683,6874
	4	12,1035		363,5513	198,8625	1392,0381
	5	12,2056		293,2945	160,4320	1123,0246

1.2.5 Perhitungan efisiensi inhibitor

1. Efisiensi inhibitor pada HCl 1M

1.1 Minggu 1

$$X_a : 252,7789 \text{ mpy}$$

$$X_b : 41,2888 \text{ mpy}$$

$$\begin{aligned} \text{Efisiensi inhibitor} &= \frac{x_a - x_b}{x_a} \times 100\% \\ &= \frac{252,7789 \text{ mpy} - 41,2888 \text{ mpy}}{252,7789 \text{ mpy}} \times 100\% \\ &= 83,66603122\% \end{aligned}$$

1.2 Minggu 2

$$X_a : 168,6320 \text{ mpy}$$

$$X_b : 49,4946 \text{ mpy}$$

$$\begin{aligned} \text{Efisiensi inhibitor} &= \frac{x_a - x_b}{x_a} \times 100\% \\ &= \frac{168,6320 \text{ mpy} - 49,4946 \text{ mpy}}{168,6320 \text{ mpy}} \times 100\% \\ &= 70,64930635 \% \end{aligned}$$

1.3 Minggu 3

$$X_a : 135,5097 \text{ mpy}$$

$$X_b : 55,7248 \text{ mpy}$$

$$\begin{aligned} \text{Efisiensi inhibitor} &= \frac{x_a - x_b}{x_a} \times 100\% \\ &= \frac{135,5097 \text{ mpy} - 55,7248 \text{ mpy}}{135,5097 \text{ mpy}} \times 100\% \\ &= 58,8776 \% \end{aligned}$$

1.4 Minggu 4

$$X_a : 102,0938 \text{ mpy}$$

$$X_b : 70,0790 \text{ mpy}$$

$$\begin{aligned} \text{Efisiensi inhibitor} &= \frac{x_a - x_b}{x_a} \times 100\% \\ &= \frac{102,0938 \text{ mpy} - 70,0790 \text{ mpy}}{102,0938 \text{ mpy}} \times 100\% \\ &= 31,3582 \% \end{aligned}$$

Dengan cara perhitungan yang sama, hasil perhitungan efisiensi inhibitor yang terdapat pada konsentrasi HCl 2M, 3M, 4M, dan 5M. Dapat dilihat pada tabel berikut :

Konsentrasi M	Waktu (Minggu)	Laju korosi		Efisiensi Inhibitor (%)
		Tanpa inhibitor (X_a)	Dengan inhibitor (X_b)	
1	1	252,7789	39,5709	84,3456
	2	168,6320	48,0778	71,4894
	3	135,5097	35,2447	73,9909
	4	102,0938	91,9750	9,9112
	5	81,6863	74,1674	9,2045
2	1	455,8135	24,4283	94,6407
	2	473,8525	83,9992	82,2731
	3	331,5744	57,4645	82,6692
	4	250,0699	57,9693	76,8187
	5	201,7473	116,4141	42,2970
3	1	457,3492	80,7660	82,3403
	2	553,1365	184,4337	66,6567
	3	408,7088	131,4911	67,8276
	4	314,5397	221,7447	29,5018
	5	270,2934	184,5893	31,7078
4	1	676,0892	81,1949	87,9904
	2	549,0111	267,4001	51,2942
	3	387,5357	192,8885	50,2269
	4	298,5849	171,5994	42,5291
	5	242,3257	143,2753	40,8748
5	1	747,2454	260,7298	65,1078
	2	604,6123	345,5388	42,8495
	3	439,7198	312,9707	28,8249
	4	363,5513	321,2110	11,6463
	5	293,2945	259,2425	11,6101